

CONFIDENTIAL

CONFIDENTIAL

50X1-HUM

Basic Types and Uses of Electric-Spark Tools

There are three basic types of electric-spark machine tools. These type groups, defined in terms of the electrode-tool set up, are: (1) advancing electrode tool, (2) rotating and advancing electrode tool, and (3) vibro-advancing electrode tool. In each of the types, hand feed, mechanical feed, hydraulic feed, or electromagnetic feed may be employed.

A partial list of operations which have proved adaptable to spark methods should include manufacture of blanking, swaging, and shearing dies; forging dies, embossing dies, press forms and chill molds, draw holes and draw plates, holes with curvilinear axes, holes of small diameter (down to 20 microns); electroprinting, electrowriting, straight-line metalcutting, curvilinear metalcutting, fine slotting (down to 120 microns); sharpening cutters and multi-edge cutting tools, flat-surface grinding, curved-surface grinding; auxiliary operations such as the extraction of broken tools and fastening parts, making screens, threads, electric hardening of metal surfaces, repair and renovation work, cleaning metal surfaces of impurities, and many other operations.

All the operations listed are performed on one of the basic types of spark machine tools listed above.

50X1-HUM

LV-14 fine-drilling machine, 1947 model

LV-15 drilling machine for precision drilling of matrixes of blanking dies, one-kilowatt feed, alternating current

50X1-HUM

LV-16 electric-spark saw, 1947 model --

LV-18, 6-kilowatt heavy-duty drill, 1947 model

electric-spark disk saw

spark unit for making embossing dies

electrode tool for making screens and a stainless-steel screen made by this tool

50X1-HUM

spark tool for hardening metal surfaces

circuit diagram of flat-grinding machine

spark-hardening unit built by Kinap Plant

electric-spark thread-cutting die

Performance

1. Cutting

The rate at which straight-line metal cutting on a spark saw proceeds may be shown by giving the cutting times for several materials of known size, all materials being cut under a fixed regime of voltage, dielectric solution, etc. Cutting times indicated in the table which follows were obtained under constant operating parameters, these parameters being the following conditions: source voltage, 25 volts; working current, up to 500 amperes; VSG-3M or mechanical rectifier of 0-100 microfarads; dielectric, 1.25-density kaolin suspension; disk, 0.7-1 millimeter sheet steel; peripheral velocity, 15 meters per second.

- 2 -

CONFIDENTIAL

CONFIDENTIAL

CONFIDENTIAL

CONFIDENTIAL

50X1-HUM

Cutting proceeds at the following rates for the following materials:

<u>Type of Stock</u>	<u>Size (mm)</u>	<u>Cutting Time</u>
Duraluminum	70 (diameter)	70 sec
Brass	70	2 min
Copper	75	3 min 20 sec
Steel 45	70	2 min 25 sec
Steel Kh-12M (raw)	70	2 min
Steel EKh	70	2 min 15 sec
Cast iron	72	2 min 40 sec
Steel 3	80	3 min 30 sec
Manganous steel	50 x 170	3 min
Steel EKh-M80G	60 x 60	1 min 45 sec
Steel Kh-12M (tempered)	75 x 160	6 min 40 sec
Zinc	80 x 135	2 min 30 sec
Lead	80 x 80	30 sec
Alnico magnetic alloy	40 x 80	1 min 40 sec
Steel RF-1	10 x 70	20 sec
Heat-resistant alloy	32 x 110	1 min 30 sec
Stainless steel	25 x 58	35 sec
Cobalt steel	27 x 23	20 sec
Beryllium	45 (diameter)	1 min 20 sec
Channel iron	No 16 (stock)	1 min 50 sec
" "	No 12	50 sec
" "	No 10	45 sec
" "	No 8	30 sec
" "	No 6.5	20 sec
" "	No 10	50 sec
" "	No 7.5	35 sec
" "	No 6	20 sec
" "	No 5	15 sec
" "	No 4	9 sec
Railroad rails	--	1 min 10 sec

- 3 -

CONFIDENTIAL

CONFIDENTIAL

CONFIDENTIAL

CONFIDENTIAL

50X1-HUM

2. Fine Drilling

Spark drilling of holes smaller than one millimeter is performed with the use of copper, brass, or wolfram wires passed through glass capillary tubes which serve as conductors.

For making holes as small as 20 microns, a 0.5-kilowatt spark unit is used; recommended voltage is 20 volts, capacitance of 0.007 microfarad, current of 0.15 ampere.

Here is an example in practice. Problem: To drill a 150-micron hole in an atomizer jet, depth of hole to be 750 microns. Setup: Use 120-micron wire, 120 volts, 0.1-microfarad capacitance, 0.25 ampere current. Hole will be drilled in 35 seconds to a tolerance of 5 microns.

Another example: A hole 0.3 millimeter in diameter and 2 millimeters deep can be drilled in 40-50 seconds using a wire 0.25 millimeter in diameter, with a circuit of 120 volts, 0.5 microfarad capacitance, and 0.5 ampere current. Taper will not exceed 15 minutes.

In both of the above examples the dielectric used was ordinary illuminating kerosene. Level of the dielectric was held to 5-10 millimeters above the surface of the work piece.

A simple variant on the above method is using an ordinary buzzer of telephone receiver, to the armature (or membrane) of which is attached a fine brass or wolfram wire. The wire, which is the cathode of the circuit, passes through a capillary tube which acts as a conductor.

Note that in all cases the conductor from which the wire emerges should not get nearer the working surface than one millimeter, since otherwise the particles which are thrown off at the point of drilling lodge in the end of the capillary tube and short out the circuit.

Spark drilling is particularly recommended for making holes in stop-cocks, fuel and atomizer apparatus, and for use in the wire industry. Drawing eyes which used to be made "blind" can easily be drilled on a spark unit.

Attention is invited to the possibilities for manufacture of complex-profiled holes of very small diameter.

3. Making Screens

Spark methods are very suitable for the making of fine perforated screens. A simple unit for this purpose consists of two sheets of insulating material with brass wires passes through them to the depth necessary. This unit, which forms the electrode tool, is then cut into an ordinary spark unit circuit, and a great number of holes can be drilled simultaneously. A screen-making tool and screen made by it are illustrated.

50X1-HUM

Electrical and Communications-Equipment Ministries
Supply Special Equipment

Alternating-current feed is generally not suitable for use with electric-spark machine tools because of the excessively heavy erosion effect on the cathode.

In selecting rectifiers for AC circuits, the following is a general recommendation: with spark units up to 0.5 kilowatt, a vacuum-tube rectifier should be used; with units up to 5-7 kilowatts, a selenium rectifier should be used.

- 4 -

CONFIDENTIAL

CONFIDENTIAL

CONFIDENTIAL

CONFIDENTIAL

50X1-HUM

[For list of selenium rectifiers manufactured by the Ministry of Communication Equipment Industry USSR, see Table 1, appended.] For units over 7 kilowatts, a direct-current motor generator, rather than a rectifier, is recommended. [For list of generators manufactured by the Ministry of Electrical Industry USSR, see Table 2, appended.]

Conversion of current by means of mechanical rectifiers has proved to be very expedient. Commutators with sliding brushes or button contacts, knife or vibrator type contacts, and also units in which a flowing liquid serves for one or both electrodes are used for switch-over units where mechanical rectification is used.

Mechanical rectifiers developed by the Central Scientific Research Laboratory for Electrical Processing of Materials and those developed by the Leningrad Academy of Forestry Engineering are excellent and are recommended for widest use.

The requirements for condensers used with electric-spark machine tools are: (1) maximum capacitance per unit of volume, (2) minimum inductance, (3) minimum loss to the dielectric, (4) the possibility of using larger lead-off wires, and (5) a high disruptive voltage.

There are two general groupings of condensers for use with electric-spark machine tools. The first consists of those condensers made by the Ministry of Communication Equipment Industry USSR which have capacitances of 2 microfarads and working voltages of 250 volts and a test voltage of 500 volts. The dimensions of these condensers are 31 x 49 millimeters, with a height of 44 millimeters.

Recently the Ministry of Electrical Industry USSR developed and produced a block of condensers (Type IM-0.22-500) specially built for use with spark machine tools. In these condensers are incorporated a maximum number of the requirements for a good spark condenser listed above. The block of condensers consists of three banks with maximum dimensions of 110 x 380 x 380 millimeters, each bank calculated for work at voltages of 220 volts and tested up to 660 volts.

The total capacitance of the block is 500 microfarads, with take-offs at the proper capacitances for the standard electric-spark condenser layout. This standard layout calls for ten take-offs at the following capacitances: 2-2-2-4-20-20-50-100-100-200 microfarads. With this combination, the following ten work regimes are possible:

At capacitances (mfd) of:	2	4	6	10	30	50	100	200	300	500
Amperes of current in feed circuit, at 220 volts:	0.16	0.32	0.4	0.8	2.4	4	8	16	24	40

Soviet industry has not as yet put out a special block of condensers for spark machine tools. As a start, the L-1 wire resistors put out by the Dinamo Plant can be used. Specifications of these are:

No of elements	21	20	19	17	16
Resistance, ohms	0.7	0.9	1.1	1.45	2.8
Permissible continuous current, amperes	19	17	17	13	9.6

- 5 -

CONFIDENTIAL

CONFIDENTIAL

CONFIDENTIAL

CONFIDENTIAL

50X1-HUM

Cross section dimensions, mm	2 x 2	2 x 1.8	2 x 1.6	2 x 1.4	2 x 1
No of turns	36 x 2	36 x 2	36 x 2	36 x 2	74

Dielectric Liquids

The following dielectric liquids are recommended for use with spark machine tools:

<u>Liquid</u>	<u>Flash Point (C)</u>	<u>Viscosity (cP)</u>
Kerosene OST-7960	28*	1.2
Diesel oil OST-305-42	66	1.5
Solar oil GOST 1666-42	130	1.5
Vaseline oil GOST 1805-42	125	1.6
Transformer oil GOST 982-41	140	1.8
Spindle oil GOST 1837-42	170	2.4
Cylinder oil GOST 1841-42	215	2.0
Aviation oil MS	230	1.9

*Before filling the spark unit with new charge of dielectric, it is absolutely essential that the flash point be verified.

Safety Measures

Many of the dangers inherent in operating conventional machine tools such as rotating parts, breaking tools, and flying chips, are obviated in the use of spark machine tools. However, particular safety measures related to the electrical nature of the operation and the danger of fire must be observed.

Numerous tests have established that the absolute safe limit of current for a man is 0.04 ampere. Current of 0.05 ampere is dangerous in that it induces a state of unconsciousness. A current of 0.1 ampere or more invariably causes death.

Since most spark units operate on 120-220-volt circuits, and since the resistance of the human body is about 1,000 ohms, it is obvious that an electric-spark machine tool is dangerous if proper precautions are not observed. The following categories of safety measures must be considered:

1. General Precautions

- a. Only workers trained in electric-spark methods and safety precautions should be allowed to operate spark tools.
- b. No work other than that for which the machine is intended should be attempted on a spark tool.
- c. The machine should be set on wooden flooring, and that part of the floor in which the worker stands should be covered with a rubber mat.
- d. The insulation at all moving connections should be checked and kept clean at all times. Do not let commutators get dirty.

- 6 -

CONFIDENTIAL

CONFIDENTIAL

~~CONFIDENTIAL~~
CONFIDENTIAL

50X1-HUM

e. Turning on the machine if the tank is not full of dielectric liquid, or covering the tank with paper, cardboard, or other flammable materials to protect clothing from splattering liquids, is strictly prohibited.

2. Before Beginning Work

- a. Get bystanders out of the area.
- b. Check your overalls and put on gloves.
- c. Check on the presence and working order of safety devices on the dangerous parts of the machine.
- d. Do not use a dielectric having a flash point below 60 degrees centigrade. Check on the flash point of each new batch of solution. This is absolutely obligatory.
- e. See that fire-extinguishing equipment is handy and in working order. It is absolutely obligatory that every unit have a sheet of felt or asbestos nearby.
- f. It is important that the light be adequate and properly shaded. There should be no glare in the worker's eyes.
- g. See that electric draw-ventilators are operating.

3. During Work

- a. Do not allow bystanders to approach the machine.
- b. Before setting electrode tool and work piece, see that the voltage is not on and that the condensers are shorted out.
- c. When the electrodes have been properly and accurately secured, observe the following order of work:
 - (1) Submerge the work piece in the tank at least 100 millimeters under the surface of the dielectric.
 - (2) See that the proper cutting regime has been selected.
 - (3) Switch on the feed current and the operating system.
 - (4) When work is finished or the work piece must be measured, turn off the operating system and disconnect the unit from the feed circuit, short out the electrode, and only after this, lower the tank.
- d. If the slightest signs of current leakage on the body of the tool are observed, stop work and disconnect the unit at once.
- e. Removal of the covers which protect the electric system of the tool is absolutely forbidden.
- f. Safety measures in the use of spark tools should be set strictly according to the current handled. Do not take advice from kibitzers under any circumstances.
- g. When the job is finished, carefully wipe the machine clean and straighten up the work station. Used cleaning materials should immediately be stored in a metal container and removed from the area at the end of the shift.

- 7 -

CONFIDENTIAL

~~CONFIDENTIAL~~

CONFIDENTIAL

CONFIDENTIAL

50X1-HUM

Table 1. Selenium Rectifiers Produced by the
Ministry of Communications Equipment Industry USSR,
Recommended for Use With Electric-Spark Machine Tools

Type	Rectified		Feed Circuit		Rectifier Type	Weight (kg)
	Voltage	Current	Voltage			
VSA-3m	0.5-80	0.25-8	220-127 single phase		Bridge	72
VSA-4	240-120	2-2	220-127-110 single phase		Bridge	60
VSA-6	12-24	24-12	220-127-110 single phase		Bridge	65
VSA-7	24-24	24-12	220-127-110 single phase		Bridge	65
VSG-3m	3.5-4.5-6	200	220-200 single phase		Full-wave type, midpoint take-off	100
VSG-4	16/8	500/1,000	220-380 3-phase		Bridge	500

Table 2. Table of Generators Manufactured by the
Ministry of Electrical Industry USSR,
Recommended for Use With Electric-Spark Machine Tools

Type and Manufac- turer	Voltage	Power at Terminals	Speed (rpm)	Input (kw)	Weight (kg)	Comments
PN-68	230	11.3	1,900	13.5	175	
PN-100	230-320	10.5	1,460	12.7	290	
PN-145	230	11.0	980	13.0	330	
MP-543-1/2	230	10.8	600	13.5	472	
ZD-4/30	24-36	4.0	1,420	--	350	Built-in input motor included in total weight
ZD-7.5/30	24-36	7.5	1,450	--	570	
AND- 1,000/500	6-12	6.0	970	--	680	

- E N D -

- 8 -

CONFIDENTIAL

CONFIDENTIAL